MODERN METHODOLOGICAL APPROACHES TO SOLVING PROBLEMS AND EXERCISES ON THE TOPIC "BLOOD CIRCULATORY SYSTEM" BASED ON THE INTEGRATION OF CHEMISTRY AND BIOLOGICAL SCIENCES

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ANNOTATION: This article analyzes modern methodological approaches to solving problems and exercises on the topic "Circulatory System," integrating biology and chemistry. It is noted that the integrated approach contributes to increasing students' interest in the subject, developing analytical and critical thinking, and deepening their understanding of interdisciplinary connections. Also, methodological recommendations are given on the example of integrated tasks created on the basis of blood composition, physiology of blood circulation, and chemical processes.

KEY WORDS: biology, chemistry, integration, blood circulation, modern methodology, hemoglobin, oxygen, affinity, problem, exercise, interdisciplinary approach.

INTRODUCTION

Today, increasing the effectiveness of the educational process, strengthening students' interest in subjects, orienting them towards practice, and equipping them with deep knowledge remains one of the pressing issues. The science of biology, due to its universality and direct connection with life, allows students to think deeply and form comprehensive approaches based on interdisciplinary connections. In the context of technological progress and the ecological crisis, teaching biological knowledge in integration with chemistry, physics, computer science, and other disciplines allows students to develop independent approaches to solving a wide range of problems. In particular, teaching biology and chemistry in close integration plays an important role not only in strengthening theoretical knowledge, but also in forming analytical and systematic thinking skills in students. Thanks to this approach, there is an opportunity for a deep understanding of interdisciplinary connections, a holistic understanding of life processes, and their scientific interpretation.

At the same time, teaching methods through interdisciplinary approaches implement the principle of "transition from knowledge to skill," which is the main goal of modern education. This not only teaches students to think independently, but also develops a sense of responsibility, group work skills, and creativity. In the process of such teaching, biology lessons are not only a source of theoretical knowledge, but also serve to prepare students for real life and increase their activity in solving problems.

Proper organization of an interdisciplinary approach and the formation of students' ability to comprehensively analyze problems serve to increase the effectiveness of teaching biology.

Interdisciplinary connections provide students with the following opportunities:

combining knowledge from different fields in the process of studying a single topic and analyzing it from a broader perspective.

Formation of creative and technical skills through the application of theoretical knowledge to real-life problems.

to create opportunities for the development of new ideas, going beyond the limits of one discipline.

Interdisciplinary integration is not a completely new direction in pedagogy, currently it is of particular importance in the formation of consistency and integrity of knowledge perceived among students, and at the same time, it is one of the ways to increase the learning activity of schoolchildren. Based on this, we

will dwell in detail on the levels and types of integration.

An integrated lesson is a type of lesson that combines knowledge from several subjects simultaneously in the study of a certain concept, topic, or phenomenon.

The objectives of an integrated lesson include:

creation of optimal conditions for the development of students' thinking in the process of teaching these subjects;

elimination of individual contradictions of the educational process;

Increasing and developing students' interest in these subjects.

Interdisciplinary integration is divided into the following components:

Object integration - the inclusion of representations of one object in different disciplines in one topic, section, or course;

Conceptual integration - covers topics or courses that reveal the content of general concepts;

in theoretical integration - theories in biology and chemistry are studied in general terms;

Methodological integration - implies the implementation of integration of individual methods of scientific knowledge;

in problem integration - interdisciplinary problems are covered and ways to solve them are developed;

in activity integration - conducting discussions on solving the problem, working in small groups, drawing up a plan of interdisciplinary events, preparing projects;

practical integration implies the acquisition of practical skills related to the studied subjects and processes that are relevant.

The implementation of interdisciplinary connections in the educational process has a strong impact on the quality of education:

allows for the modernization of education, expanding the possibilities of innovative training;

plays an important role in ensuring continuity and consistency in general secondary and secondary specialized education;

Inclusion of issues aimed at ensuring interdisciplinary communication in the content of programs, textbooks, and teaching aids imposes important tasks on pedagogical scientists and researchers;

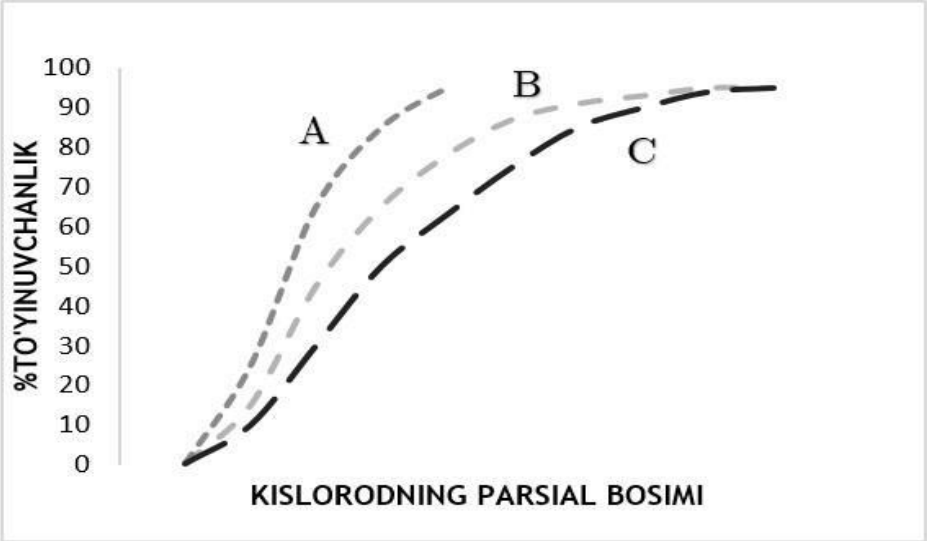
the development of interdisciplinary communication models based on educational technologies is one of the pressing issues of today.

The importance of the integrated learning methodology is especially evident in the study of complex biological systems, such as the circulatory system. The circulatory system provides all cells in the body with nutrients, oxygen, and other necessary compounds, and also participates in the removal of excess substances and maintaining homeostasis. These processes occur not only according to biological, but also according to chemical laws. For example, such concepts as the distribution of gases in blood in relation to pressure in solutions, ionic equilibrium, and the pH level are directly related to chemistry.

Modern pedagogical approaches, in particular, the development of problems and exercises in biology and chemistry through integrated learning, STEAM technology, problem-based learning, visual and interactive methods, serve to form a deep and stable understanding of the topic in students. Through integration tasks based on the circulatory system, not only theoretical knowledge is developed, but also life competencies, such as understanding a healthy lifestyle, a conscious attitude to physiological processes, and the formation of a scientific worldview.

This article highlights the modern methodological foundations of problems and exercises developed based on the integration of chemistry and biology within the framework of the topic of the circulatory system, their role in increasing students' interest in the subject, as well as their role in ensuring the effectiveness of teaching.

Task 1. Hemoglobin (Hb) was accidentally discovered by Hunefeld in 1840 in blood samples of earthworms under two glass preparations. Hemoglobin is a protein that provides the main transport of blood in erythrocytes. The graph below shows how oxygen binds to a hemoglobin molecule over time. The affinity of the hemoglobin molecule for O2 can change according to certain principles.



Q1. Study this graph and align the given three axes (A-C) with the following.

1	Normal Hb/O_2 line	
2	Fetal Hb/O_2 line	
3	Hb/O_2 line with low blood pH	

Solution and analysis of the problem:

1. On the graph, three different curves (A, B, C) show the saturation of hemoglobin relative to oxygen in relation to the partial pressure of oxygen. This graph shows hemoglobin's affinity for oxygen. It has a sigmoidal shape, which is a sign of the cooperative phenomenon (that is, when one O_2 combines, it combines more easily with others).

2. Analyze line A (Left line):

Despite low O_2 pressure, hemoglobin quickly saturates with O_2. This indicates high affinity for oxygen. This property is characteristic of fetal hemoglobin (HbF). Because the fetus needs to get oxygen from the mother's blood. Then A = 2.

3. Let's analyze line B (Middle Line):

This is a normal shape, a standard sigmoidal graph. At medium pressures, saturation is high, but not excessively affinity. This is a typical graph of hemoglobin (HbA) in an adult. Then B = 1.

4. Let's analyze line C (Right line):

This graph is shifted to the right: that is, the saturation is lower at the same O_2 pressure. This indicates a decrease in hemoglobin affinity for O_2. This occurs when the pH of the blood decreases (i.e., the environment becomes acidic). Then C = 3.

1	Normal Hb/O_2 line	B
2	Fetal Hb/O_2 line	A
3	Hb/O_2 line with low blood pH	C

This problem is integrated with the science of chemistry through the following aspects.

№	Biological state	Chemical base
1	O_2 binding and release	Equilibrium reaction, Le Chatelier's principle
2	pH effect	H^+ ions
3	HbF vs. HbA difference	Molecular structure, haemoglobin protein
4	Hb - O_2	Coordination bond, complexation (Fe^{2+} - O_2)

As shown in the graph, the degree of hemoglobin oxygen saturation varies depending on oxygen pressure and pH. These changes are controlled by chemical balances, ions, and bonding forces.

Task 2. In the vessels of an adult's body, there is 5 liters of blood. Hemoglobin accounts for 14% of the blood in men and 13% in women. If one gram of hemoglobin contains 1.3 ml of oxygen, how much oxygen is there in the blood of men and women? (1 ml = 1 g).

Solution and analysis of the problem:

1) 5 l = 5000 ml = 5000 g

2) 5000 g — 100 %

x g — 14 % — x = 700 g of hemoglobin in male blood

y g — 13 % — y = 650 g of hemoglobin in a woman's blood

3) 1 g hemoglobin — 1,3 ml O_2

700 g hemoglobin — x ml — x = 910 ml O_2 in men

650 gr gemoglobin — y ml — y = 845 ml O_2 in women

Answer: A man's blood contains 910 ml of O_2, and a woman's blood contains 845 ml of O_2.

This problem is integrated with chemistry through the following aspects.

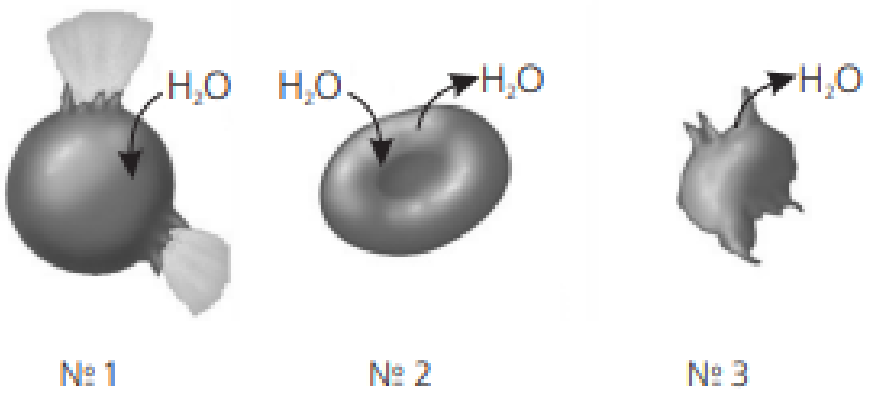
№	Biological aspect	Chemical base
1	Lung → tissue oxygen transport	Coordination bond, equilibrium
2	Effect of pH change	H^+ ions
3	Oxygen volume	Mol, gas law, mol volume calculations
4	Role of Fe^{2+}	Central ion, complexing agent

Oxygen transport in the body is a biological process that has a deep chemical basis. The Fe^{2+} ion, located at the center of the hemoglobin molecule in the blood, forms a coordination bond with oxygen molecules. This process operates not only according to physicochemical laws but also creates an entry point for oxidation-combustion reactions, which are the main energy source for cell activity.

In the problem, there is an opportunity to capture as much oxygen as there is hemoglobin. From a chemical point of view, this is a stoichiometric relationship, that is, it is determined by the relationship between the mass, volume, and number of moles of a substance. 1 gram of hemoglobin binds 1.3 ml of oxygen - this is the same quantitative chemistry.

This also happens when the pH level decreases (for example, when more H+ ions appear), and hemoglobin releases oxygen more easily. This is a biological expression of the principles governing acid-base balance.

Task 3. Below are erythrocytes placed in 3 different media. Determine the concentration of these solutions.



Solution and analysis of the problem:

1. This figure shows how erythrocytes (red blood cells) react when placed in various media. By changing their shape, one can conclude about the concentration of the solution (i.e., hypotonic, isotonic, or

hypertonic).

2. In Figure 1, the erythrocyte is swollen due to water entering it. Therefore, this hypotonic solution contains a lot of water in the external environment, and water enters the erythrocyte through osmosis.

3. In Figure 2, the shape of the erythrocyte is unchanged. Therefore, this isotonic solution - the concentration of water and solution inside and outside the erythrocyte - is equal, and water exchange is in equilibrium.

4. In Figure 3, water has leaked from the erythrocyte; it has shrunk and wrinkled. In the solution, the concentration of salt is high, the concentration of water is low, and in the erythrocyte, the concentration of salt is low, the concentration of water is high. Therefore, it is considered a hypertonic solution.

Answer: №1 - Hypotonic solution; №2 - Isotonic solution; №3 - Hypertonic solution.

This problem is integrated with the science of chemistry through the following aspects.

Chemistry explains this phenomenon by the concentration of solutions. A solution with a low concentration is hypotonic, in which case water enters the erythrocyte. A solution of equal concentration is called isotonic, in which the inlet and outlet of water are in equilibrium. A solution with a high concentration is hypertonic, in which case water leaks from the erythrocyte.

Thus, the shape and state of erythrocytes depend on what solution they are immersed in, i.e., on the chemical composition of the solution. This shows the close relationship between biological processes (osmosis) and chemical properties (concentration, osmotic pressure).

In the modern education system, it is important to implement interdisciplinary integration, especially through the combination of chemistry and biology, to form students' scientific thinking and teach them to solve problems based on a comprehensive approach. Methodological approaches developed on the basis of the topic “Circulatory System” develop students' skills in applying theoretical knowledge in practice, increase interest in science, and encourage scientific analysis of life problems.

The integrated tasks, practical exercises, and methods based on students' independent research presented in this article serve to increase the effectiveness of the educational process. These approaches not only increase the level of students' knowledge, but also prepare them for critical thinking, conducting scientific research, and social activism.

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